Measurements and Simulation Results in Support of IEEE 802.3bj Objective

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Agenda

- Measurement setup
- Cable Results
  - Measured: 3m, 5m
- Backplane Results
  - Measured: 0.6m
  - Simulated: 1m
- Proposal for longer backplane channels
- Summary

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Supporters

- Iain Robertson, TI
- Tom Palkert, Xilinx
- Scott Kipp, Brocade
- Myles Kimmitt, Emulex
- Mike Dudek, Qlogic

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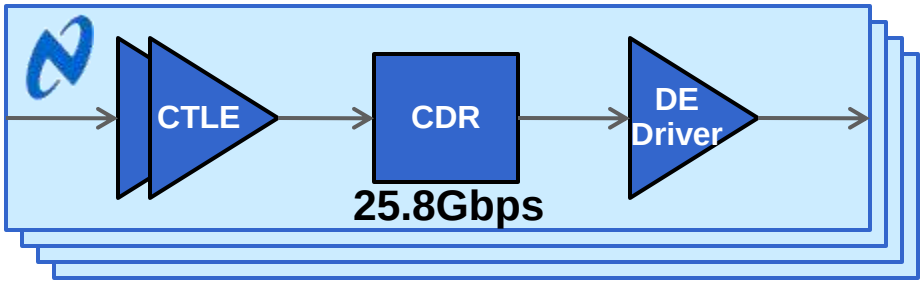
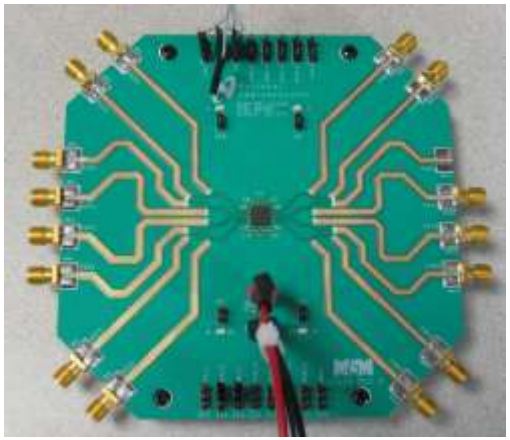
Measurement Setup Details





NSC Retimer Eval Board

- 4-Channels
- NRZ Encoding
- CTLE front end
- LC-VCO based CDR
- DE Driver

Molex zQSFP+ Eval Board

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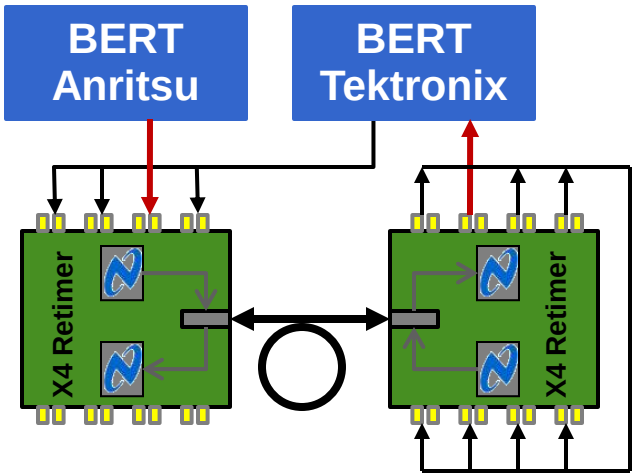
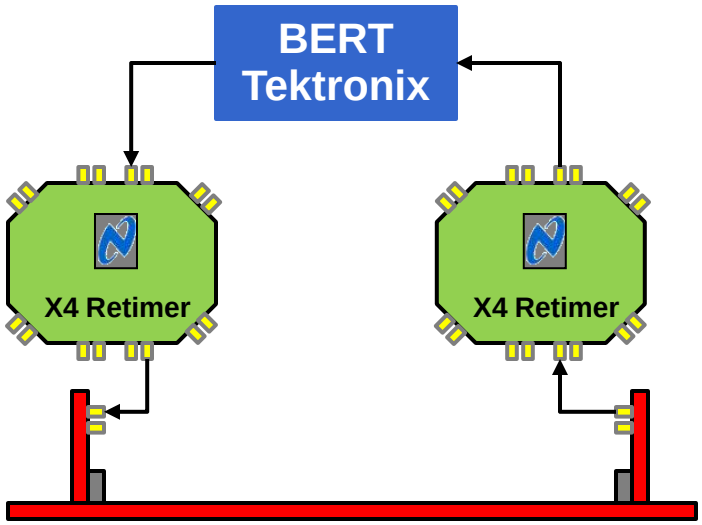
Measurement Setup Details

Cable Setup



- Integrated board
  - Nelco 4000-13Si, 2.5” stripline
  - zQSFP+ connectors
  - 2x NSC Retimers
  - On-board AC coupling
- Molex cables: 3m, 5m, 24AWG
- 2nd BERT for asynchronous Xtalk

Backplane Setup



- 2x NSC Evaluation boards
  - Rogers, 3” microstrip
- Molex Backplane
  - Impact connectors, Meg-6
  - Daughter cards, Meg-6
- External DC blocks, SMA cables
- No Xtalk (only one BERT available)

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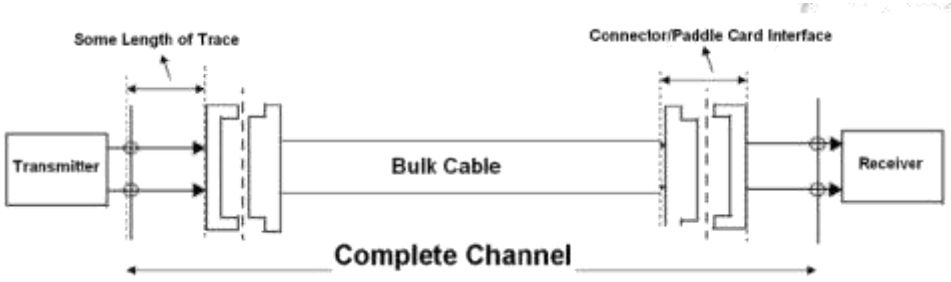
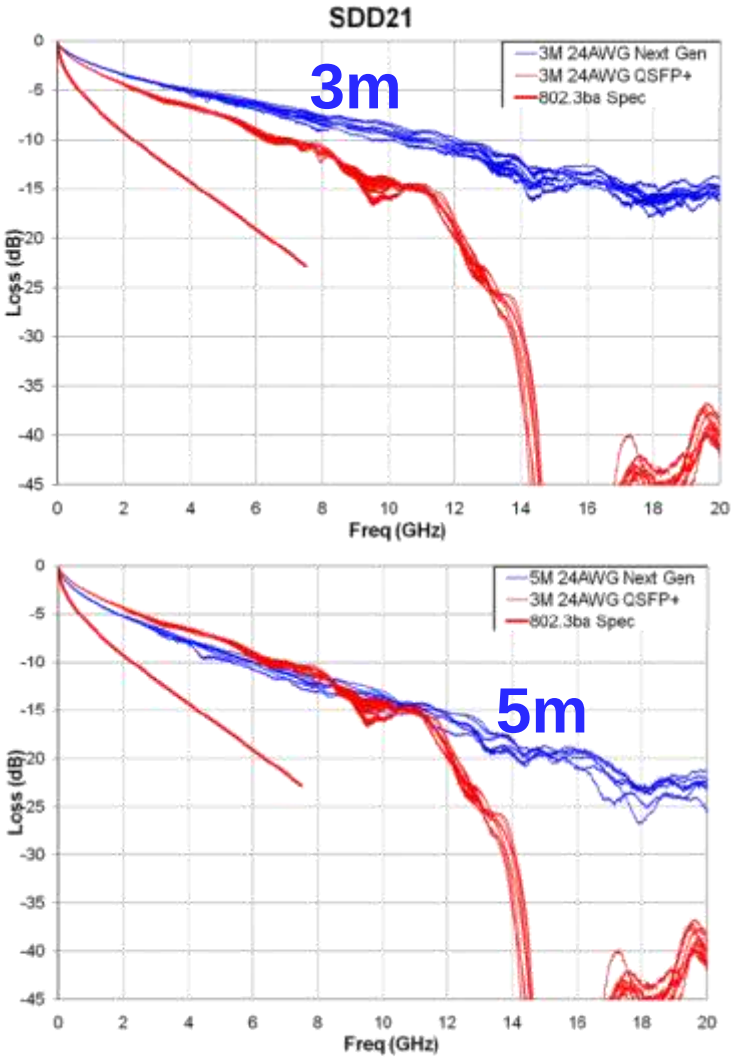
Cable Results

Measurement results – Molex cables

- Channel Characterstics
  - From bugg_010111.pdf
  - 24AWG
- Cable IL: 3m 15dB; 5m 17dB
- Host Board IL: ~4dB
- Total IL: 3m ~22dB; 5m ~24dB
- *Channels independently analyzed by Intel (pg 21, 22)*

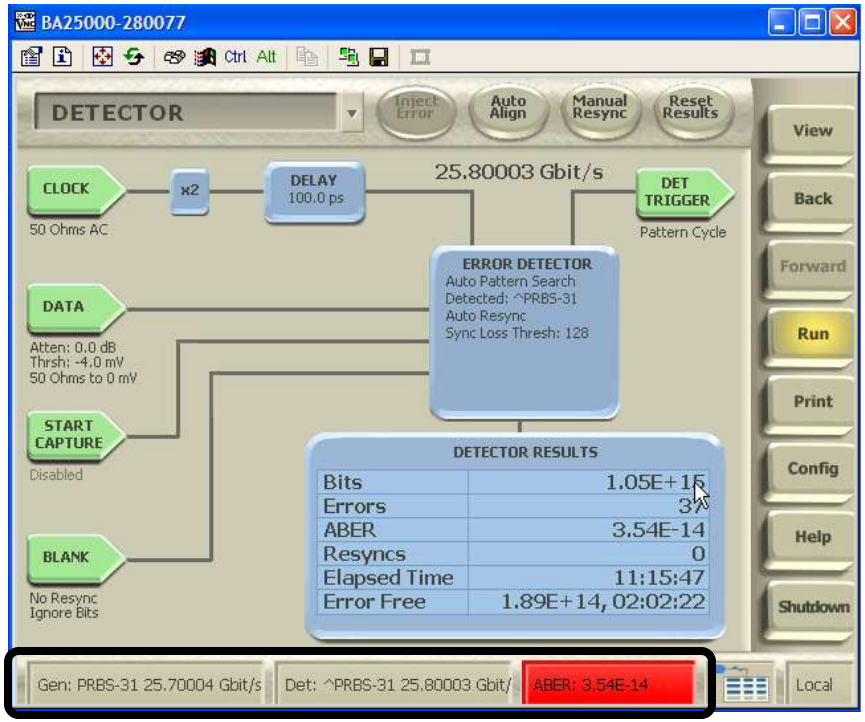


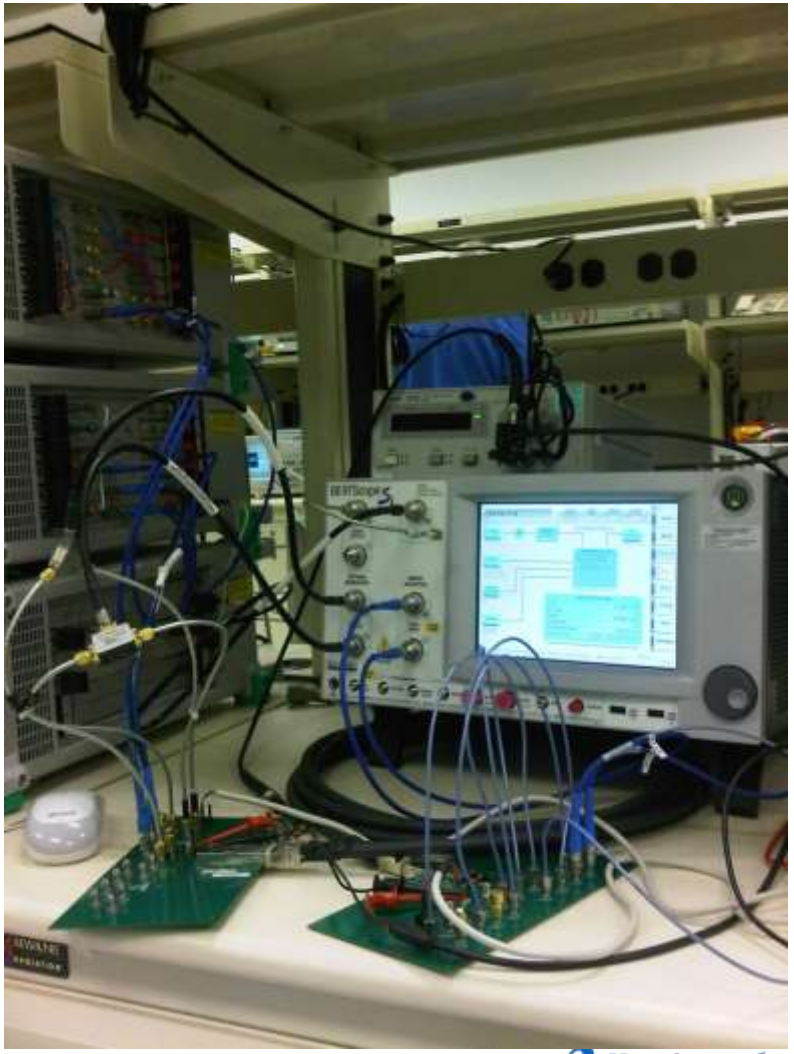
- Some Length of Trace:
  - 4.7dB will be allotted for each side
- Connector/Paddle Card Interface (including Termination) and Bulk Cable
  - 3M 24AWG: ~ 14.82dB @ 12.89 GHz
  - 5M 24AWG: ~ 17dB @ 12.89 GHz
- Complete Channel using 3 Meters =
  - 14.82 dB (from above) + 2 x 4.7 (Trace) = 24.22 dB
- Complete Channel using 5 Meters =
  - 17 dB (from above) + 2 x 4.7 (Trace) = 26.4 dB



Measurement Results – 3m Molex Cable

- **BER < 1e-13**
  - **PRBS-31, 25.8Gbps**
- **Asynchronous crosstalk**
  - **7 aggressors, 1 victim**





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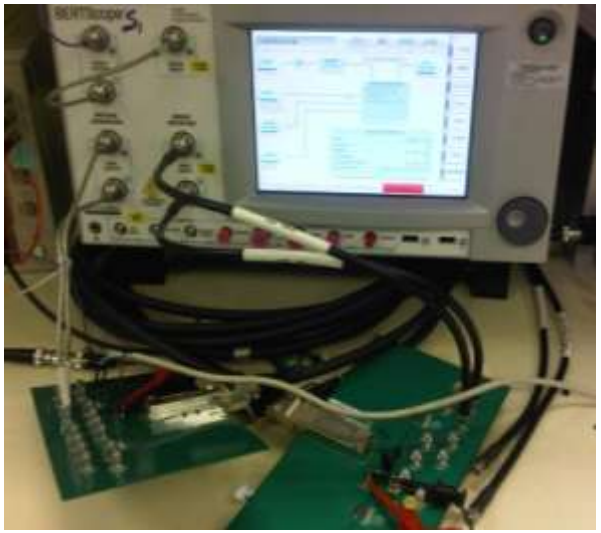
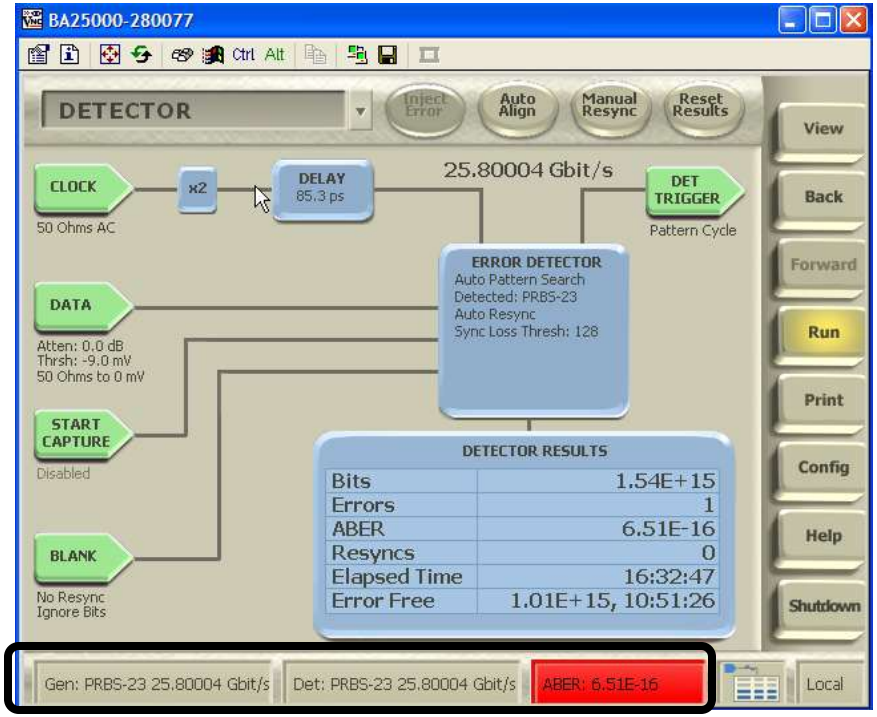
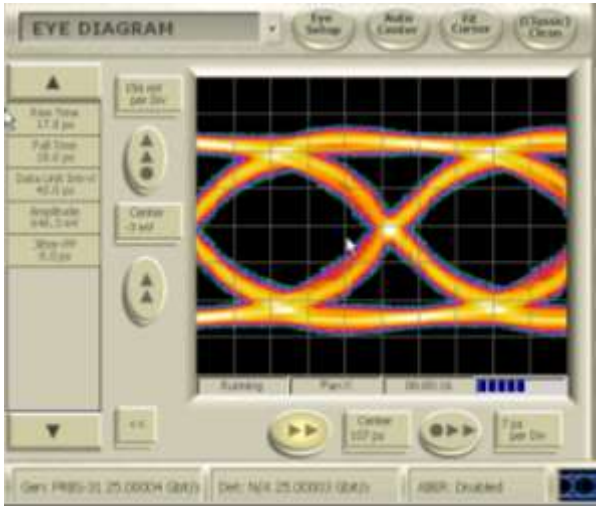
Measurement Results – 5m Molex Cable

- **BER < 1e-15**
- **No crosstalk**
- **Performance limited by max EQ**







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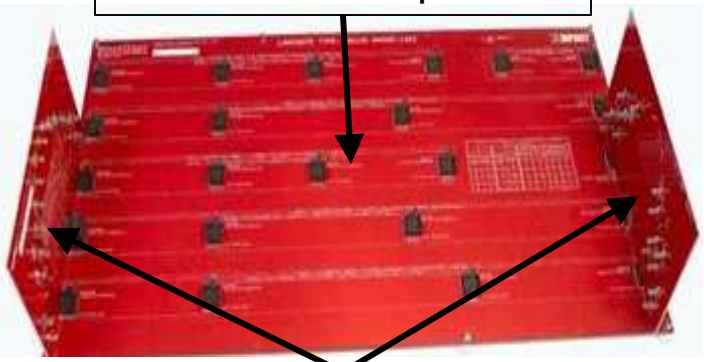
Backplane Results

Measurement Results – Molex Backplane

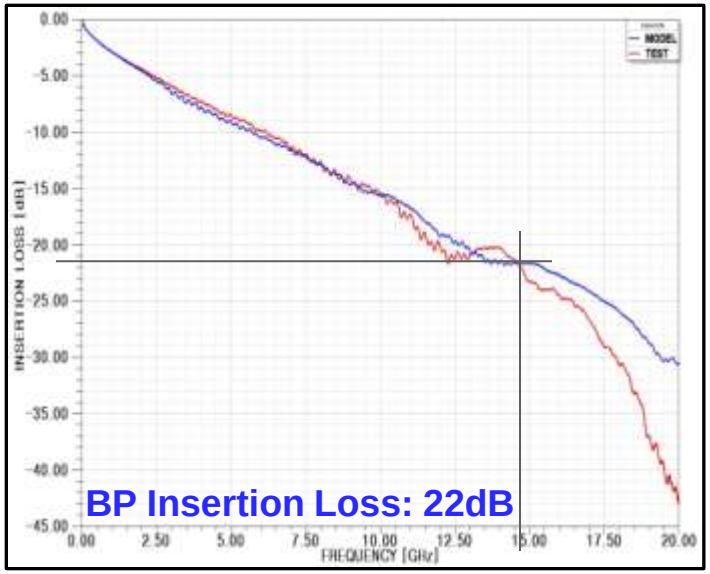
Backplane Construction

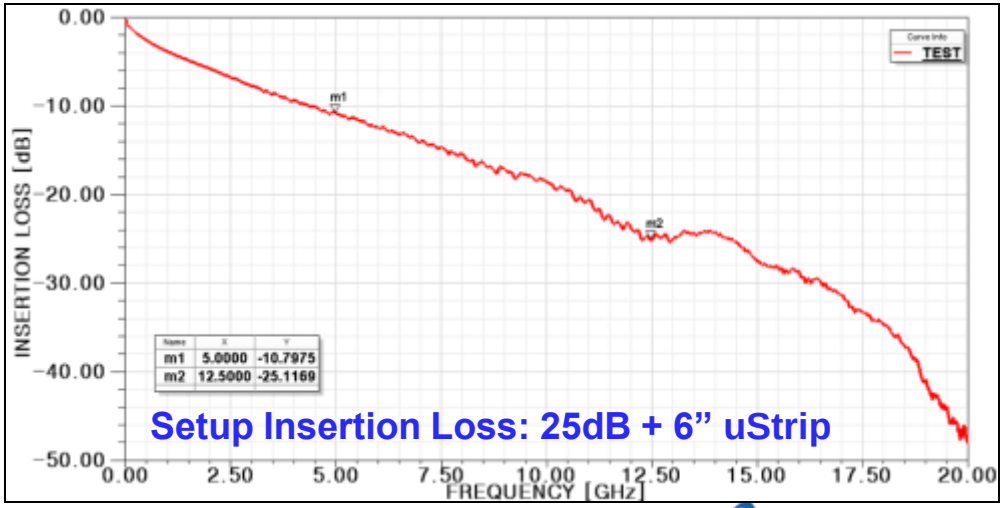
- **Total channel length: 0.6m**
- **PCB Material:**
  - **DC: Megtron 6 (VLP Copper)**
  - **BP: Megtron 6 (HVLP Copper)**
- **Trace width/spacing/width:**
  - **DC: 5.7/9.3/5.7 mils**
  - **BP: 7/9/7 mils**
- **15mil via stubs on BP/DC**

Molex Impact™ Reference Backplane



Molex Impact™ Daughter Card





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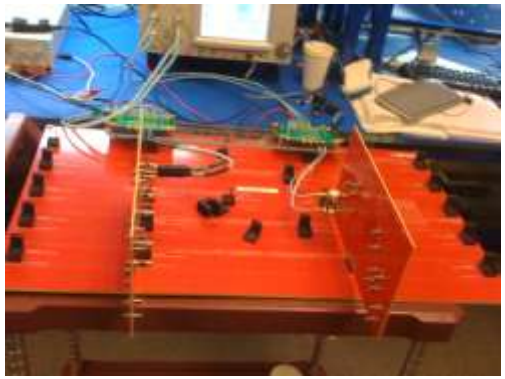
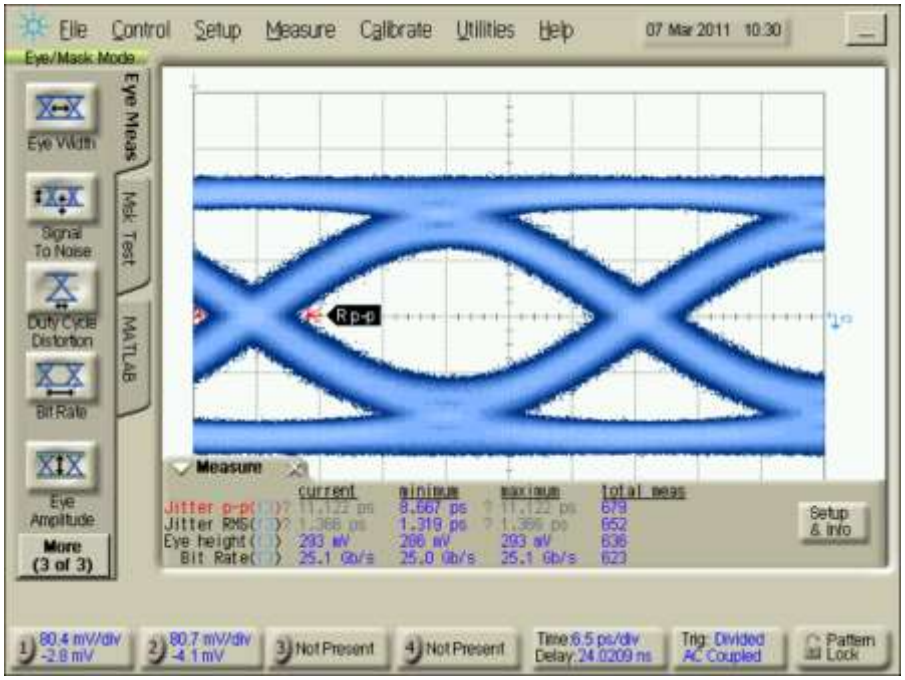
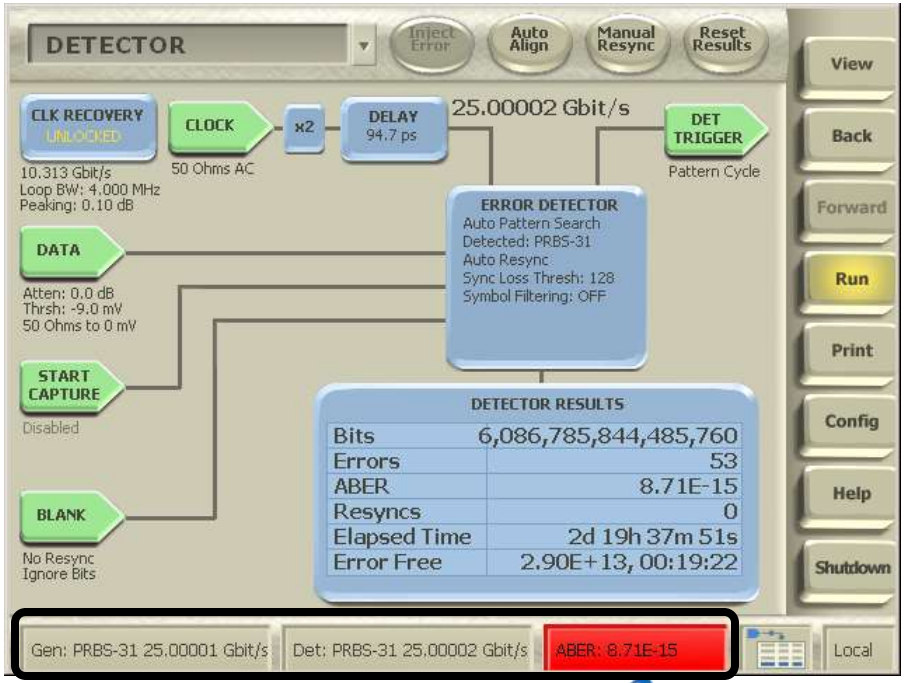
Measurement Results – Molex Backplane

- **BER < 1e-14**
- **No crosstalk**
- **Performance limited by measurement setup, max EQ**







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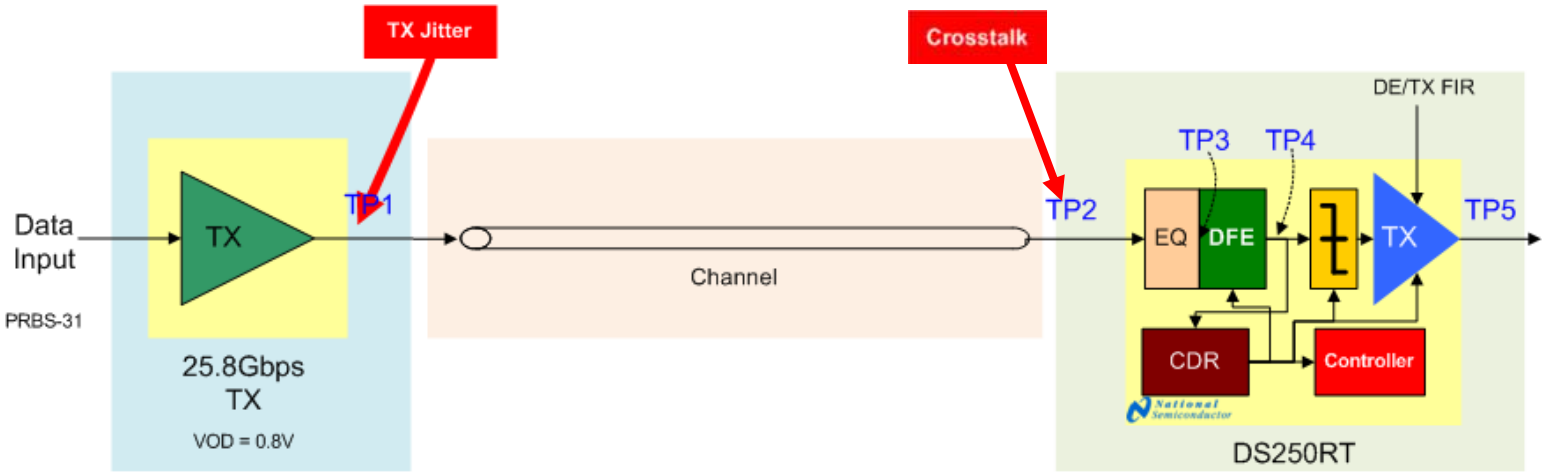
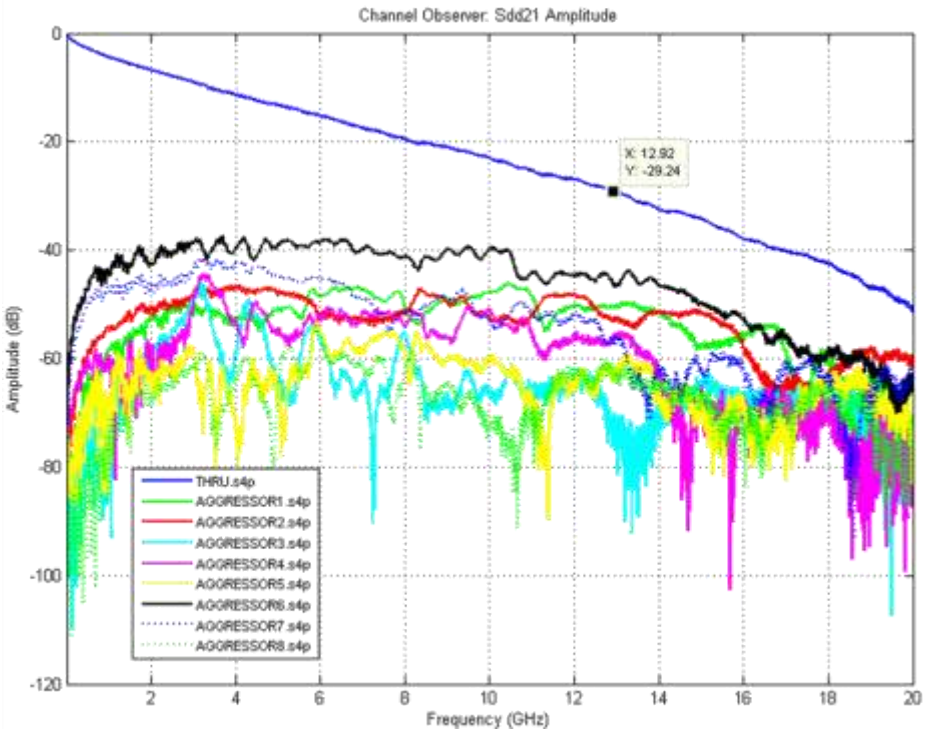
System Simulations

- **Matlab based SI simulation tool**
  - **Correlated with lab measurements**
  - **Time domain analysis for deterministic effects**
  - **Overlay statistical analysis for random effects**
  - **S-parameter channel model including crosstalk**
    - **25% higher aggressor, asynchronous frequency, PRBS-23**
  - **Package model**
  - **Transmit model: 0.8Vpp; 3-tap FIR; 2.8ps DJ, 0.28UI TJ @ 1e-15**



IBM 1m Channel Characteristics

(Sep'11 contribution by Pravin Patel)

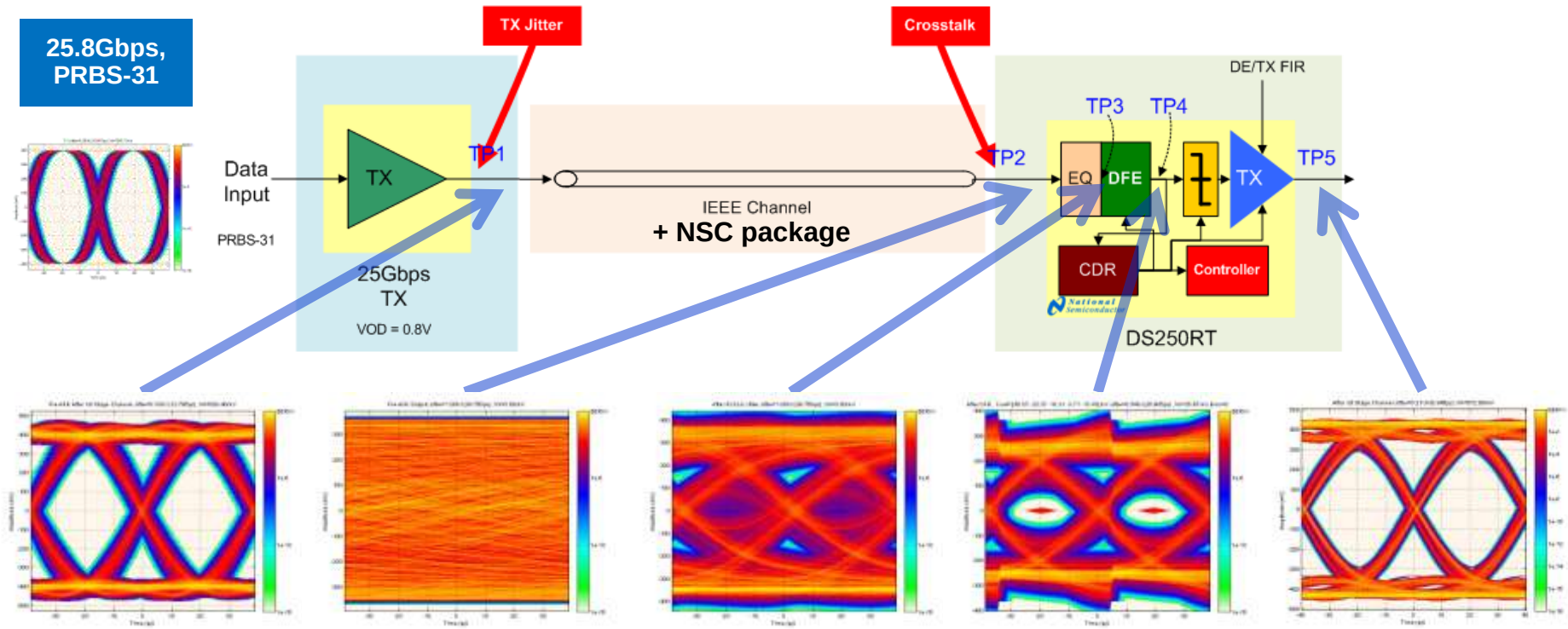


IBM 1m Backplane Channel (Ref: *patel_2_0911.pdf*)

- **Channel Characteristics Summary**
  - **Insertion Loss: -30dB @ 12.9GHz (No significant discontinuities)**
  - **Worst Crosstalk: -44dB @ 12.9GHz (#6 out of 8 crosstalk aggressors)**

IBM 1m Channel Simulation Results

(Sep'11 contribution by Pravin Patel, ***patel_2_0911.pdf****)*



TP1: After package
Jitter = 0.33UI
$V_{eye\text{-}height}$ = 630mV
$V_{peak\text{-}peak}$ ≈ 800mV
TX FIR = [0,1,0]

TP2: After IBM 1m Channel
Jitter = 1UI
$V_{eye\text{-}height}$ = 0V

TP3: After CTLE
Jitter = 1UI
$V_{eye\text{-}height}$ = 0mV

TP4: After DFE
Jitter = 0.54UI
$V_{eye\text{-}height}$ = 36mV

TP5: Retimer Output
Jitter = 0.21UI @ BER<10^{-15}
$V_{eye\text{-}height}$ = 572mV
$V_{peak\text{-}peak}$ ≈ 900mV

Notes:
- ***IEEE 25Gbps TX Jitter: 2.8s DJ, 0.28UI TJ at BER < 10^{-15}***
- ***TX V_{OD} = 0.8V, Aggressor V_{OD} = 1V***
- ***8 Asynchronous Crosstalk Aggressors***
- ***Simulation BER Setting: 10^{-15}***

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Proposal for Longer Reach (>1m or legacy backplanes)

Background

- Several presenters have shown that it is possible to meet 1m objective with ‘improved FR-4’ and NRZ encoding
  - IBM, Altera, Vitesse, Intel, etc. at previous IEEE meetings
- Broadcom has shown that it maybe possible to meet 99% KR channels with PAM4
- In practice, only a very small fraction of KR channels with loss >30dB and poor ICR are targeted at 25Gbps
  - Most OEMs have used better materials and/or connectors
  - There is flexibility in redesigning line cards with better material
- An alternate scheme to handle such channels is presented

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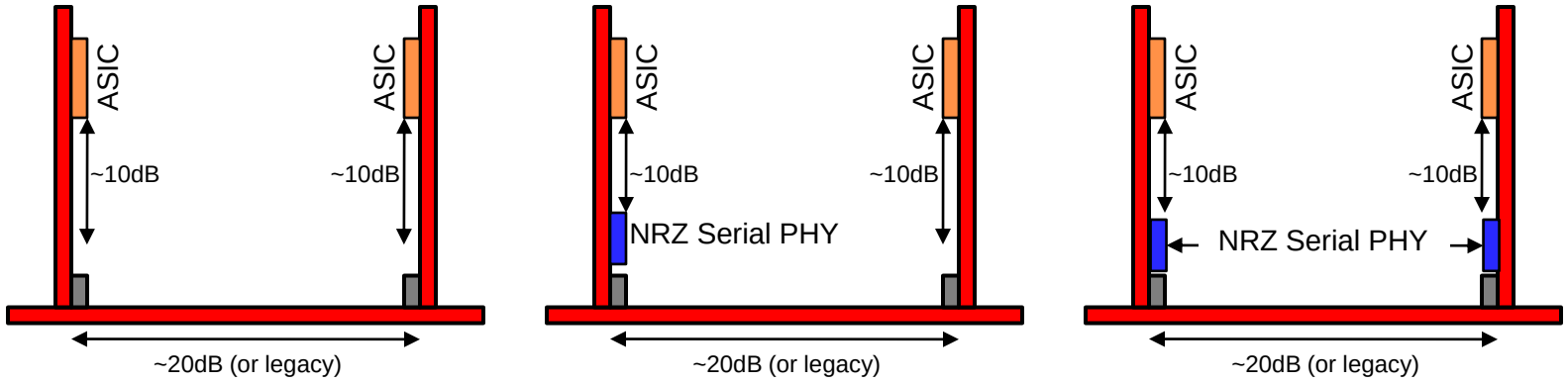
Long reach proposal

- **Break the longest links into two or three segments**
  - **Consider the following example for a 40dB loss channel that may prove difficult for NRZ**
  - **End to end loss: 40dB**
  - **Two segments: 30dB and 10dB**
  - **Three segments: 10dB, 20dB and 10dB → theoretically >>40dB!**



- **Benefits**
  - **Extend the reach of NRZ beyond 40dB**
  - **Retain the benefits of NRZ – backward compatibility, forward integration etc.**
  - **No $$ penalty for majority of 25G links that are much better than KR**

Summary

- **Demonstrated feasibility to 100GCU objectives**
  - Silicon results from 25dB insertion loss channels
    - NRZ encoding, no FEC
    - 5m zQSFP+ cable with expected host traces
    - 0.6m Backplane + ~6dB setup losses
  - Room for improvement
    - Performance limited by setups and receive capability
      - Significant improvement with DFE enabled
      - Incremental improvement from better measurement setup
    - Simulations show 1m over improved backplane easily achievable
- **Data Encoding**
  - NRZ sufficient for 1m BP, 5m cable IEEE 100GCU objective
  - Proposal to enable longer reach over legacy backplanes using NRZ
  - Single PHY for backplane and front port applications

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Thank You!